The role of IUCAF at the ripe old age of 60

Harvey Liszt , Chair

IUCAF
Radio Astronomy
Space Science
iucaf.org

NRAO NSF Associated Universities, Inc.

What is IUCAF?

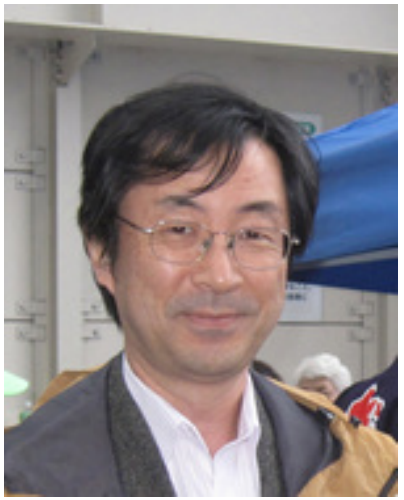
IUCAF's map of radio telescopes/quiet zones

tinyurl.com/yrvszk

IUCAF Chairs 1960 - now

Figure 1 The six chairmen of IUCAF. *Top*: J-F. Denisse (1960–1964), F.G. Smith (1964–1975). *Middle*: J.P. Hagen (1975–1981), J.W. Findlay (1981–1987). *Bottom*: B.J. Robinson (1987–1995), W.A. Baan (1995–1999). In March 1999 Klaus Ruf became chairman.

Darrel Emerson 2000-2002

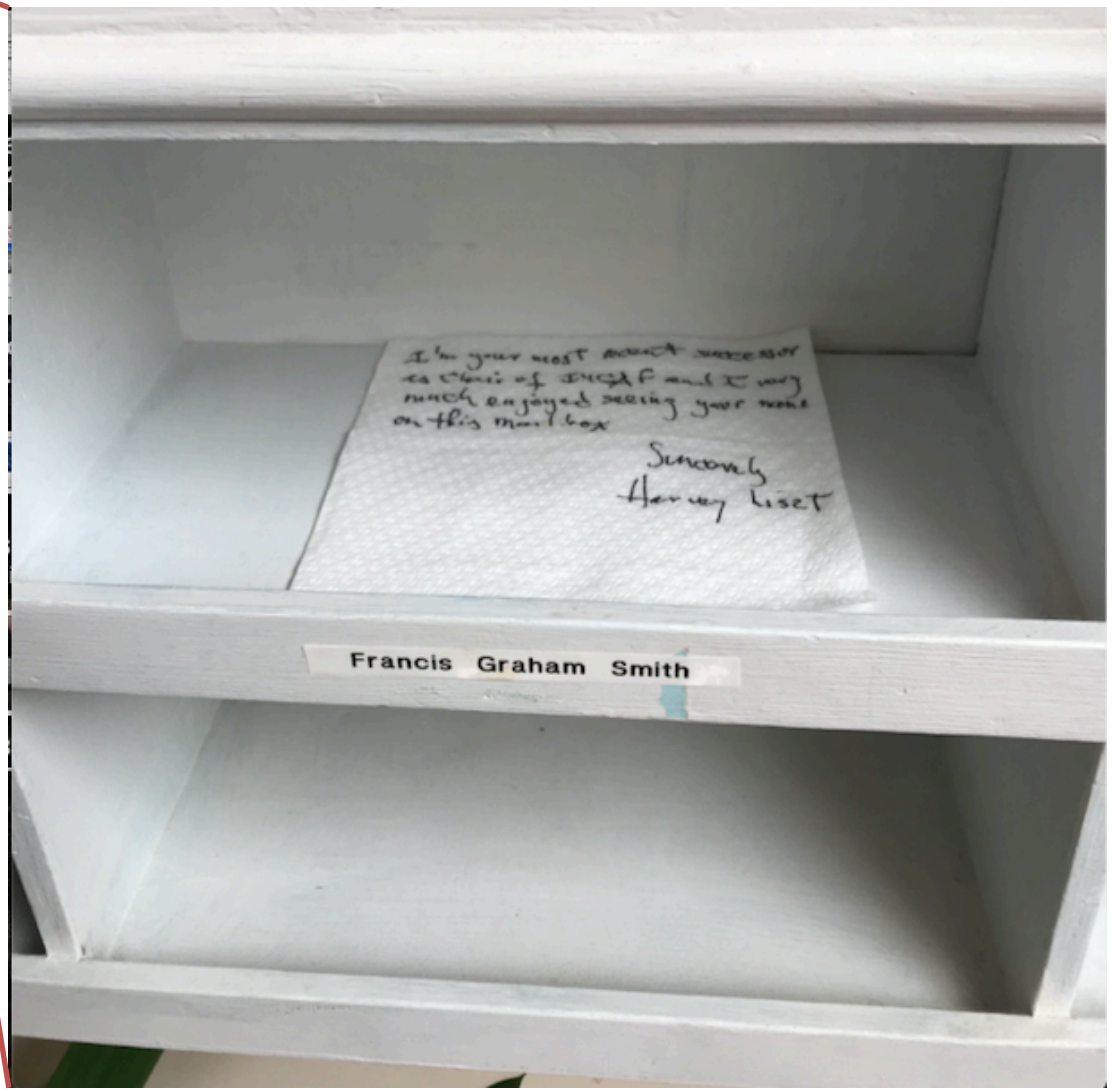


Masatoshi Ohishi 2009-2015

Wim van Driel 2003-2009

Harvey Liszt 2015-

Jodrell Bank, June 2019



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I.U.C.A.F AND FREQUENCIES FOR RADIO ASTRONOMY

JOHN W. FINDLAY
Senior Scientist at the National Radio Astronomy Observatory until retirement in 1985

International Astronomical Union Colloquium No. 112 Page 195

https://tinyurl.com/sygkq7c

https://tinyurl.com/yxyheela

Annu. Rev. Astron. Astrophys. 1999. 37:65–96

FREQUENCY ALLOCATION: The First Forty Years

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Key Words Frequency management, IUCAF, world radio conferences, radio interference, mobile satellites, radio astronomy

■ **Abstract** In 1960 ICSU set up an Inter-Union Commission (IUCAF) on the Allocation of Frequencies for Space Research and Radio Astronomy, to keep key parts of the radio spectrum clear for passive, scientific use. IUCAF represents URSI, IAU and COSPAR at World Radio Conferences (WRCs) convened by the International Telecommunications Union (ITU) in Geneva; the WRCs establish the international law which governs users of the radio spectrum. This review recounts many serious threats posed to passive scientific research by commercial and military operations, particularly those involving radio emissions from aircraft and spacecraft. The continual conflict between commercial greed and scientific curiosity has often put the future of radio astronomy, space research, and earth exploration in jeopardy. The conflict increases as we move into the Information Age.

Figure 1 The six chairmen of IUCAF. *Top*: J-F. Denisse (1960–1964), F.G. Smith (1964–1975). *Middle*: J.P. Hagen (1975–1981), J.W. Findlay (1981–1987). *Bottom*: B.J. Robinson (1987–1995), W.A. Baan (1995–1999). In March 1999 Klaus Ruf became chairman.

What was going on in the 60's?

The Administrative Radio Conference, Geneva, October 1959 allocated 1400–1427 MHz to the RAS in near-absolute terms:

Allocation to Services		
Region 1	Region 2	Region 3
1 350 — 1 400	**1 350 — 1 400**	
FIXED MOBILE RADIOLOCATION	RADIOLOCATION	
349	349	
1 400 — 1 427		
RADIO ASTRONOMY		
350		

350 In Albania, Bulgaria, Hungary, Poland, Roumania, Czechoslovakia and the U.S.S.R., the band 1 400-1 427 Mc/s is also allocated to the fixed service and the mobile, except aeronautical mobile, service.

What was going on in the 60's?

They say, if you remember the 60's you weren't really there

The Administrative Radio Conference, Geneva, October 1959 allocated 1400–1427 MHz to the RAS in near-absolute terms:

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Region 1	Region 2	Region 3
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But for other "radioastronomy" bands the table was like:

Allocation to Services		
Region 1	Region 2	Region 3
401 — 406 METEOROLOGICAL AIDS *Fixed* *Mobile* except aeronautical mobile 314 315 316 317		
406 — 420 FIXED MOBILE except aeronautical mobile 314 317		

RAS allocations lacked status

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317 **The band 404-410 Mc/s in Regions 2 and 3, and the band 406-410 Mc/s in Region 1 are also allocated to the radio astronomy service.** An appropriate continuous band within these limits shall be designated on a national or area basis. In making assignments to stations of other services to which these bands are allocated, administrations are urged to take all practicable steps to protect radio astronomy observations from harmful interference. The radio astronomy service shall be protected from harmful interference from services operating in other bands in accordance with the provisions of these Regulations, only to the extent that these services are protected from each other.

What was going on in 1960?

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This became a superfluous 5.149

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This text became part of 4.6

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The International Science Council charters IUCAF

https://council.science/

International Science Council

Research Programmes

- Data and Information
- Committee on Data for Science and Technology (CODATA)
- World Data System (WDS)
- INASP
- Frequencies for Radio Astronomy & Space Science (IUCAF)

Overview

The International Science Council (ISC) is a non-governmental organization with a unique global membership that brings together 40 international scientific Unions and Associations and over 140 national and regional scientific organizations including Academies and Research Councils.

The ISC was created in 2018 as the result of a merger between the International Council for Science (ICSU) and the International Social Science Council (ISSC).

The International Council for Science (ICSU) was the International Council of Scientific Unions (ICSU) until 2015.

The Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science (IUCAF) is an international committee (set up in 1960 by URSI, IAU, and COSPAR) that works in the field of spectrum management on behalf of the passive radio sciences, like radio astronomy, remote sensing, space research, and meteorological remote sensing.

Terms of Reference are Approved by ISC's EC

International Science Council

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- Data and Information
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http://www.iucaf.org/IUCAF_Terms_Of_Reference.pdf

CONSTITUTION AND TERMS OF REFERENCE OF IUCAF: THE SCIENTIFIC COMMITTEE ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE
September 2015

The terms of reference are as follows:

a) To study the requirements for frequency bands and radio frequency protection for research in the fields of radio astronomy and space science;
b) To co-ordinate these requirements for the three constituent bodies which may set up special committees for this purpose;
c) To formulate proposals for frequency allocations which are adequate to meet these requirements;
d) To bring these proposals to the attention of the appropriate national frequency allocation authorities with the assistance of the national member bodies which may establish joint national committees for this purpose;
e) To initiate necessary action to get these proposals placed on the agenda of the ITU;
f) To initiate such other action as is deemed appropriate under the charter of ICSU to ensure favourable action on these proposals by the ITU-R and ITU;
g) To note that any formal communication from IUCAF to ITU-R or ITU will be sent on behalf of the three bodies by the IUCAF Chair.

Concentration on getting new allocations was reasonable until 2000 but getting new allocations is unlikely now

Why aren't we getting new allocations?

International Science Council

Research Programmes

- Data and Information
- Committee on Data for Science and Technology (CODATA)
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We would dearly love to have strong protection for the 6.67 GHz methanol maser line, for instance

But getting a new allocation requires showing that your proposed use is compatible with existing uses

If that were true, RAS wouldn't need an allocation

Why aren't we getting new allocations?

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Even allocations we "don't need" could be useful

International Table		
Region 1 Table	Region 2 Table	Region 3 Table
50.2-50.4 EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) 5.340		

ALMA's RQZ doesn't protect it in bands not allocated to radio astronomy on a primary basis

Why aren't we getting new allocations?

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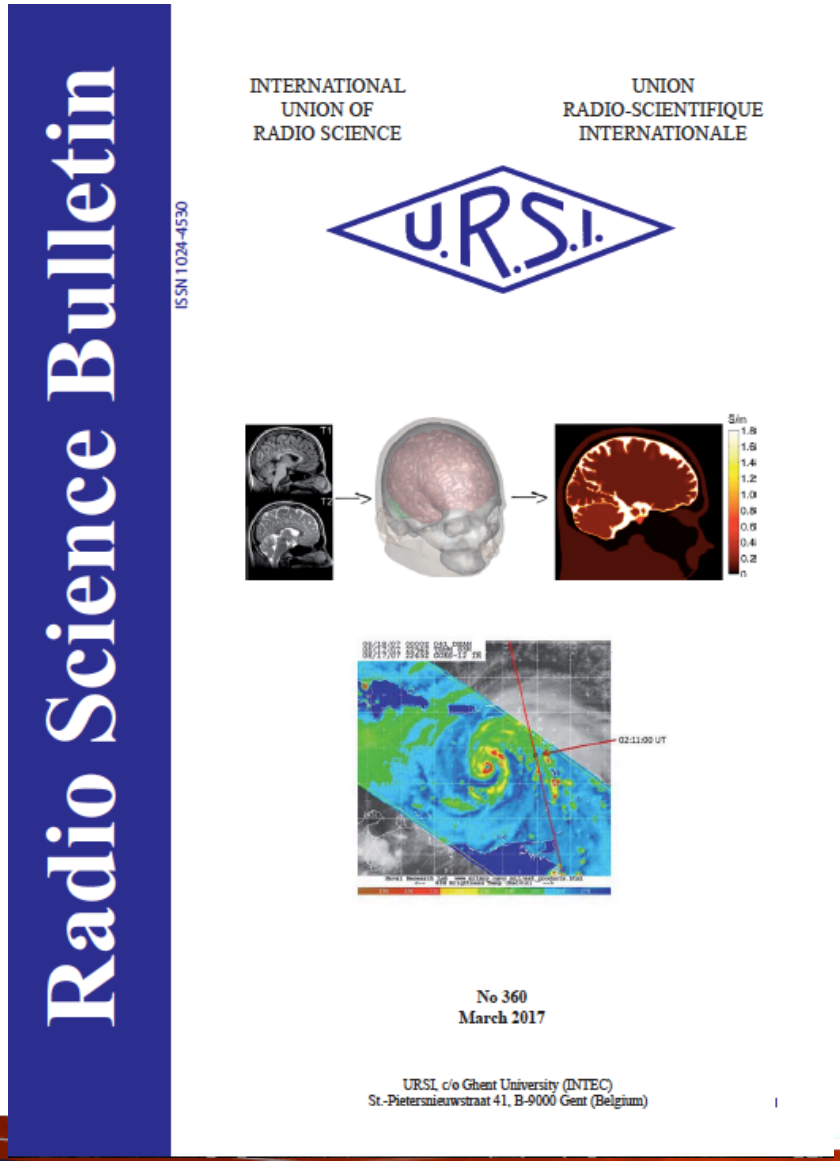
If that were true, RAS wouldn't need an allocation

It's very unlikely that RAS would be compatible at 6.67 GHz, HAPS alone would contradict that

New shared allocations would be a good hedge against future development in that band

Active service operators are sure to realize that

URSI Oversees IUCAF, Finances



IUCAF's annual report is sent to ISC, IAU, URSI and COSPAR and published in the URSI Radio Science Bulletin

IUCAF reports to the IAU GA, URSI GASS and ICS when asked

Cover: (Upper figure) The steps used to create the volume conductor models used for the paper. The MRI data were first segmented, and then the surfaces obtained were used to voxelize the segmented model. See the paper by Marko Mikkonen and Ilkka Laakso in the special section on "The Best Papers from the EMTS 2016 Young Scientist Awards", pp. 13-18.

(Lower figure) Passive microwave imagery from the NASA TRMM satellite, depicting the eyewall replacement cycle in Hurricane Dean on August 17, 2007, at 2254 UTC. All images are from the 85 GHz channel, in which ice scattering reveals areas of deep convection displayed in the red shades (image courtesy of the Naval Research Laboratory, NRL). See the paper by Michel Parrot in the special section on "Radio Science for Humanity: URSI-France 2017 Workshop", pp. 75-79.

IUCAF is a few people

IAU Representatives to Other Organizations

IUCAF

Scientific Committee on Frequency Allocations For Radio Astronomy and Space Science

Chair: Harvey Liszt
hliszt@nrao.edu

Masatoshi Ohishi
masatoshi.ohishi@nao.ac.jp

Adrian Tiplady
atiplady@ska.ac.za

Too few! Two or three lacking from IAU

IUCAF is a few people

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Fort Collins, Colorado
80523-1373, USA

IUCAF is a few people

Union Radio-Scientifique Internationale — URSI — International Union of Radio Science

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Australia Telescope National Facility (ATNF)
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IUCAF Executive

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Vice-chair: **Vacant!**

Immediate Past Chair: Masatoshi Ohishi
National Astronomical Observatory of Japan
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Mitaka, Tokyo,
181-8588, Japan

ex-officio

Vadim Nozdrin
International Telecommunications Union
Place des Nations
CH-1211 Genève 20
Switzerland

What is IUCAF?

The IUCAF brief is to study and coordinate the requirements for radio frequency allocations established by the afore-mentioned sciences and to make these requirements known to the national and internationl bodies responsible for frequency allocations. IUCAF has official standing as a non-voting organization at the ITU, the International Telecommunication Union, located in Geneva, Switzerland; it is a Sector Member of ITU-R.

IUCAF takes action aimed at ensuring that disruptive emissions do not interfere with the above sciences (when operating within allocated bands) by other radio services. IUCAF is particularly concerned about radio transmissions from aircraft, space vehicles, and land-based telecom services.

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What's going on now?

Conference Preparatory Meeting (CPM)

YOU ARE HERE HOME > ITU-R > STUDY GROUPS > CPM

What did IUCAF do?

IUCAF provided radio astronomy's views on agenda items of concern, and radio astronomy's markup of the CPM & WRC-19 treaty text

ITU-R CPM19.02 C

ITU-R CPM19.02

Second Session of the Conference Preparatory Meeting for WRC-19

Results: **248** total items.

Result page: Previous - 1 - 2 - 3

[25]	Proposed modification to the draft CPM text Chapter 5 - Agenda items 1.8 (Issue B), 1.9.1, 1.9.2	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[24]	Proposed modifications to the draft CPM text Chapter 4 - Agenda item 1.7	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[23]	Proposed modifications to the draft CPM text Chapter 3 - Agenda items 1.6 and 9.1.9	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[22]	Proposed modifications to the draft CPM text Chapter 2 - Agenda item 1.13	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[21]	Proposed modifications to the draft CPM text Chapter 1 - Agenda items 1.11, 1.14 and 1.15	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
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Reward Iridium for 20 years of bad behaviour killing 1612 MHz OH? (yes)

Coastal Maritime at 160 MHz vs RAS at 322 MHz

Maritime MSS 156.0125-157.4375 & 160.6125-162.0375 MHz

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MOD

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ANNEX 1 TO RESOLUTION 739 (REV.WRC-19)

Unwanted emission threshold levels

epfd thresholds[1] for unwanted emissions from all space stations of a non-GSO satellite system at a radio astronomy station

Space service	Space service band	Radio astronomy band	Single dish, continuum observations		Single dish, spectral line observations		VLBI		Condition of application: the API is received by the Bureau following the entry into force of the Final Acts of:
			epfd[2]	Reference bandwidth	epfd[2]	Reference bandwidth	epfd[2]	Reference bandwidth	
	(MHz)	(MHz)	(dB(W/m²))	(MHz)	(dB(W/m²))	(kHz)	(dB(W/m²))	(kHz)	
MSS (space-to-Earth)	137-138	150.05-153	−238	2.95	NA	NA	NA	NA	WRC-07
MMSS (space-to-Earth)	157.1875-157.3375 161.7875-161.9375	150.05-153	−238	2.95	NA	NA	NA	NA	WRC-19

What did IUCAF do?

IUCAF provided radio astronomy's views on agenda items of concern, and radio astronomy's markup of the CPM & WRC-19 treaty text

Reward Iridium for 20 years of bad behaviour killing 1612 MHz OH? (yes)

Coastal Maritime at 160 MHz vs RAS at 322 MHz

Maritime MSS 156.0125-157.4375 & 160.6125-162.0375 MHz

ANNEX 1 TO RESOLUTION 739 (REV.WRC-19)

Unwanted emission threshold levels

epfd thresholds[1] for unwanted emissions from all space stations of a non-GSO satellite system at a radio astronomy station

Space service	Space service band	Radio astronomy band	Single dish, continuum observations		Single dish, spectral line observations		VLBI		Condition of application: the API is received by the Bureau following the entry into force of the Final Acts of:
			epfd[2]	Reference bandwidth	epfd[2]	Reference bandwidth	epfd[2]	Reference bandwidth	
	(MHz)	(MHz)	(dB(W/m²))	(MHz)	(dB(W/m²))	(kHz)	(dB(W/m²))	(kHz)	
MSS (space-to-Earth)	137-138	150.05-153	−238	2.95	NA	NA	NA	NA	WRC-07
MMSS (space-to-Earth)	157.1875-157.3375 161.7875-161.9375	150.05-153	−238	2.95	NA	NA	NA	NA	WRC-19
MMSS (space-to-Earth)	157.1875-157.3375 161.7875-161.9375	322-328.6	−240	6.6	−255	10	−228	10	WRC-19

What did IUCAF do?

IUCAF provided radio astronomy's views on agenda items of concern, and radio astronomy's markup of the CPM & WRC-19 treaty text

Reward Iridium for 20 years of bad behaviour killing 1612 MHz OH? (yes)

Coastal Maritime at 160 MHz vs RAS at 322 MHz

Maritime MSS 156.0125-157.4375 & 160.6125-162.0375 MHz

[25]	Proposed modification to the draft CPM text Chapter 5 - Agenda items 1.8 (Issue B), 1.9.1, 1.9.2	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[24]	Proposed modifications to the draft CPM text Chapter 4 - Agenda item 1.7	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[23]	Proposed modifications to the draft CPM text Chapter 3 - Agenda items 1.6 and 9.1.9	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[22]	Proposed modifications to the draft CPM text Chapter 2 - Agenda item 1.13	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[21]	Proposed modifications to the draft CPM text Chapter 1 - Agenda items 1.11, 1.14 and 1.15	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science
[20]	IUCAF views on WRC-19 agenda items of concern to Radio Astronomy	Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science

HAPS

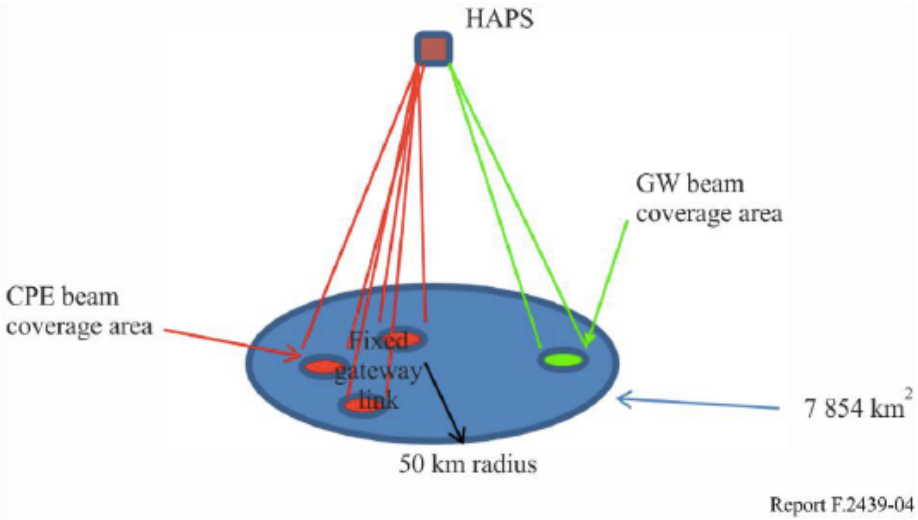
Land Mobile, FS 275 - 450 GHz

High Altitude Platform Stations AI 1.14 WRC-19

1.66A *high altitude platform station:* A *station* located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth.

FIGURE 4

Example CPE beam gateway beam and HAPS coverage



High Altitude Platform Stations AI 1.14 WRC-19

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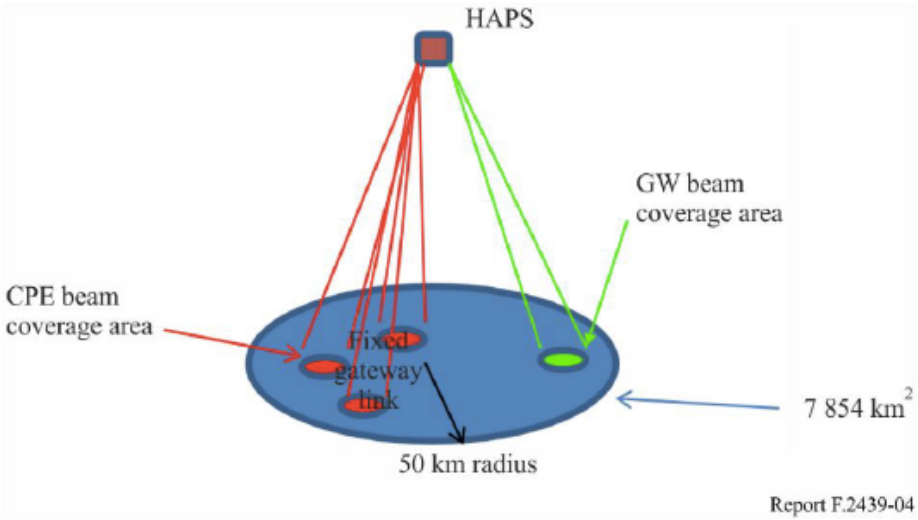
Report ITU-R F.2439-0
(11/2018)

FIGURE 4

Example CPE beam gateway beam and HAPS coverage



Report F.2439-04

Report ITU-R F.2439-0
(11/2018)

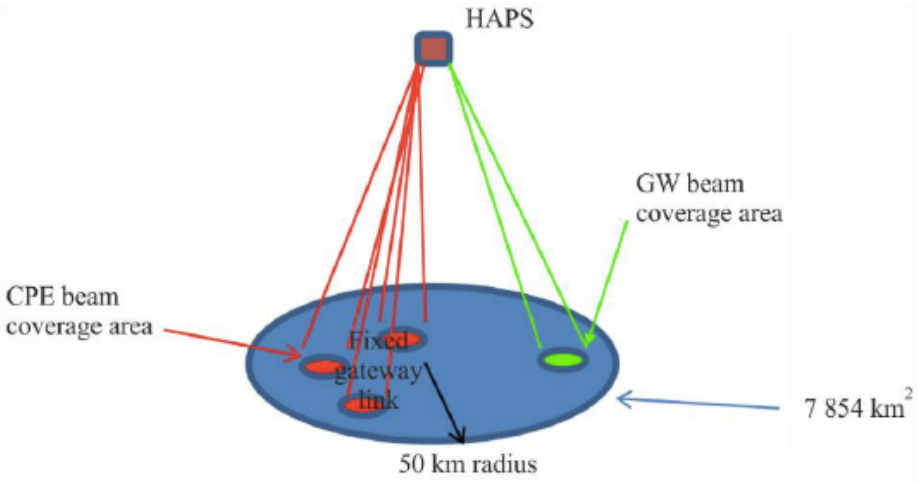
Deployment and technical characteristics of broadband high altitude platform stations in the fixed service in the frequency bands 6 440-6 520 MHz, 21.4-22.0 GHz, 24.25-27.5 GHz, 27.9-28.2 GHz, 31.0-31.3 GHz, 38.0-39.5 GHz, 47.2-47.5 GHz and 47.9-48.2 GHz used in sharing and compatibility studies

High Altitude Platform Stations AI 1.14 WRC-19

Report ITU-R F.2439-0
(11/2018)

FIGURE 4

Example CPE beam gateway beam and HAPS coverage



Report F.2439-04

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A platform at 20 km is visible for 510 km at sea level and a full buildout of HAPS would put 81 platforms above the horizon

HAPS are not actually fixed

Report ITU-R F.2439-0
(11/2018)

FIGURE 4

Example CPE beam gateway beam and HAPS coverage

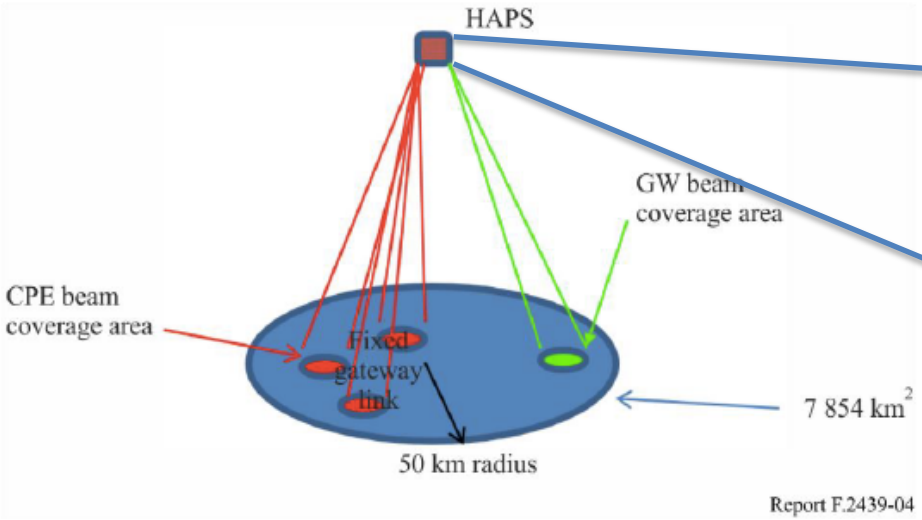
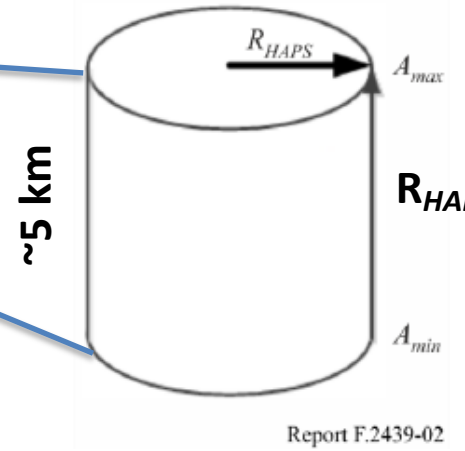


FIGURE 2

HAPS volume of movement



R_{HAPS} ~ 5 km

A platform at 20 km is visible for 510 km at sea level and a full buildout of HAPS would put 81 platforms above the horizon at sea level

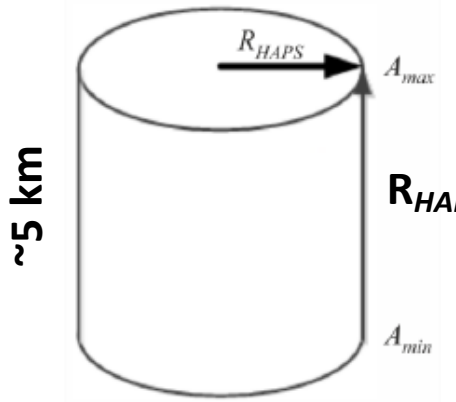
HAPS are not actually fixed

Report ITU-R F.2439-0
(11/2018)

HAPS systems studied did not have platform – end user links

FIGURE 2

HAPS volume of movement



Report F.2439-02

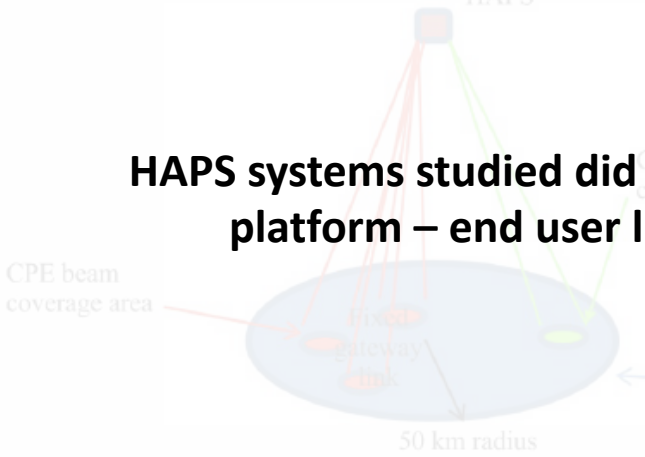
R_{HAPS} ~ 5 km

A platform at 20 km is visible for 510 km at sea level and a full buildout of HAPS would put 81 platforms above the horizon

HAPS are not actually fixed

Report ITU-R F.2439-0
(11/2018)

FIGURE 4
Example CPE beam gateway beam and HAPS coverage



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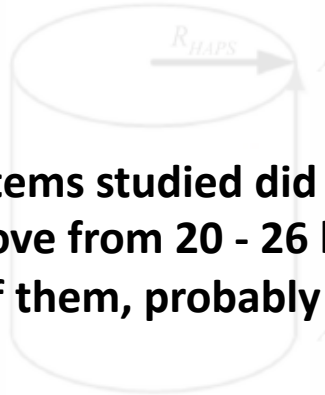
HAPS volume of movement



Report F.2439-02

HAPS systems studied did not have platform – end user links

HAPS systems studied did not orbit radially or move from 20 - 26 km but there were 81 of them, probably too many

A platform at 20 km is visible for 510 km at sea level and a full buildout of HAPS would put 81 platforms above the horizon

How was HAPS supposed to be compatible?

- 2% dataloss is a standard for RAS (ie RA. 1513)
- Did compatibility by analogy with the GSO belt
  - HAPS will block no more than 2% of the sky
    - In bands allocated to radio astronomy
    - In 2% of sky RAS would see harmful interference
  - 3^{o} cone of avoidance for RAS around each platform
  - Would require HAPS unwanted emissions to remain 30 dB below RA 769 at all time at pre-registered RAS sites

How was HAPS supposed to be compatible?

- An idealistic solution problematic for RAS
  - 60 dB stronger HAPS inband signals always visible
    - Would be 100+ dB stronger if RAS points them
    - Could fry an RAS receiver in the worst case
  - HAPS circulate unpredictably
  - HAPS are widely visible across national borders
  - *HAPS are only obliged to protect pre-registered RAS sites*

A nasty twist

- Draft Methods all had a 2020 sunset date for protection

4 that *resolves* 3 above applies at any radio astronomy station that was in operation prior to 22 November 2019; and that has been notified to the Bureau in the band 22.21-22.5 GHz before 22 May 2020. Radio astronomy stations notified after this date may seek an agreement with administrations that have notified HAPS,

- Changes had to be worked in many places in CPM text

4 that *resolves* 3 shall apply ~~above applies~~ at any radio astronomy station that was in operation prior to 22 November 2019; and that has been notified to the Bureau in the band 22.21-22.5 GHz before 22 May 2020, or at any radio astronomy station that was notified before the date of receipt of the complete Appendix 4 information for coordination or notification, as appropriate, for the HAPS system to which *resolves* 3 applies. Radio astronomy stations notified after this date may seek an agreement with administrations that have notified HAPS,

Thanks to IUCAF's booking agent

SCIENTIFIC COMMITTEE ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE

IUCAF

The IUCAF brief is to study and coordinate the requirements for radio frequency allocations established by the afore-mentioned sciences and to make these requirements known to the national and internationl bodies responsible for frequency allocations. IUCAF has official standing as a non-voting organization at the ITU, the International Telecommunication Union, located in Geneva, Switzerland; it is the face of radio astronomy at ITU-R

IUCAF takes action aimed at ensuring that disruptive emissions do not interfere with the above sciences (when operating within allocated bands) by other radio services. IUCAF is particularly concerned about radio transmissions from aircraft, space vehicles, and land-based telecom services.

(Thought leadership reflection)

Enabling radio astronomy through ITU-R

Harvey Liszt

Chair, IUCAF

Radio astronomy, spectrum management and WRC-19

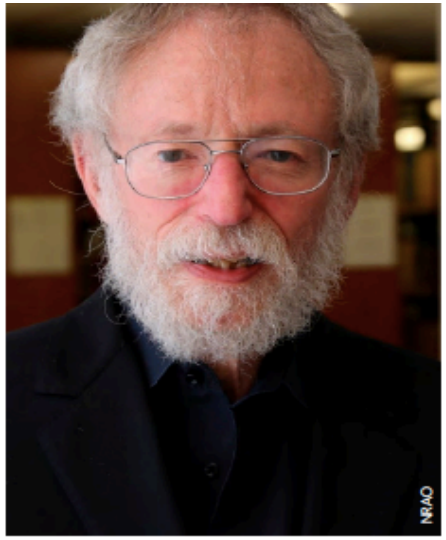
Harvey Liszt

Spectrum Manager, National Radio Astronomy Observatory, (NRAO) and Chair, IUCAF

Astronomy is the study of our place in the universe, and the radio astronomy service is responsible for many exciting discoveries in this grand endeavour. Whether imaging massive black holes in the centres of distant galaxies or watching new planetary systems form around nearby stars, radio astronomy's success depends on careful management of radio spectrum. Radio astronomy will be strongly affected by the outcomes of the World Radiocommunication Conference 2019 (WRC-19), so it is a great privilege to contribute to this special edition of the ITU News Magazine.

Radio telescopes driven to "remote" sites

The discovery of cosmic radio waves by Karl Jansky in 1932 and the discovery of radio emission from the primordial Big Bang by Penzias and Wilson in 1964 were by-products of measurements to determine the noise contributions to telecommunication systems.



“Whether imaging massive black holes in the centres of distant galaxies or watching new planetary systems form around nearby stars, radio astronomy's success depends on careful management of radio spectrum.”

Harvey Liszt

The ITU-R is IUCAF's speakers bureau, booking agent

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International Satellite Communication Symposium 2016

PRO

Harvey Liszt, Chair IUCAF/National Radio Astronomy Observatory, USA, speaking at the International Satellite Communication Symposium 2016.

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